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Description and Bibliography of Dams

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**DESCRIPTION AND BIBLIOGRAPHY
OF DAMS**

BY

ALFRED NALLE ABBOTT

THESIS

FOR THE

DEGREE OF

BACHELOR OF SCIENCE

IN

CIVIL ENGINEERING

IN THE

COLLEGE OF ENGINEERING

UNIVERSITY OF ILLINOIS

1911

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May 25, 1911

This is to certify that the thesis prepared under my personal supervision by ALFRED NALLE ABBOTT entitled Description and Bibliography of Dams is approved by me as meeting this part of the requirements for the degree of Bachelor of Science in Civil Engineering.

Ira O. Baker

Head of Department of Civil Engineering.

संस्कृत-विश्व-विद्यालय

INTRODUCTION.

As the writer intends to practice in a country which is comparatively undeveloped, and where it is difficult to secure reliable information embodying the best engineering practice, he has deemed it useful to secure a complete set of references to the literature relating to the design and construction of dams, and to make a study of such features of the design of dams applicable to different conditions.

The object of this thesis is the classification of the principal types of fixed dams and the description of the general features of each. No attempt will be made to enter into the theoretical considerations governing the design as this matter is fully treated in other works. Drawings of actual works of construction are given to illustrate each type. References are made to articles in engineering periodicals dealing with the design and construction of different dams.

GENERAL CLASSIFICATION. Dams may be classified as fixed or movable, according to whether they are overflow and act as a weir, or have a spillway; and with reference to the material out of which they are constructed, as timber, earth, masonry, and steel. The last classification is here developed.

TITLES AND ABBREVIATIONS.

In the references the following notation is used;

All dimensions are in feet.

H denotes greatest height of dam above the stream bed.

TW " top width.

BW " greatest bottom width.

L " total length.

R " radius.

w denotes weekly.

m " monthly.

bi " bi-monthly.

q " quarterly.

yr. " yearly.

Aust. Min. Stand.- Australian Mining Standard. v. Melbourne.

Calif. Jour. of Tech.- California Journal of Technology. v.

Berkely.

Can. Engr.- Canadian Engineer. v. Toronto and Montreal.

Cassier's Ma.- Cassier's Magazine. v. New York and London.

Engr.- Engineer. v. London.

Engng.- Engineering. v. London.

Engng. Con.- Engineering Contracting. v. New York.

Eng. & Min. Jour.- Engineering and Mining Journal. v. New York.

Eng. News.- Engineering News. v. New York.



- Eng. Rec.- Engineering Record. w. New York.
- Jour. W. Soc. Engs.- Journal of the Western Society of Engineers.
bm. Chicago.
- Jour. Assn. Eng. Soc.- Journal of the Association of Engineering
Societies. m. Boston, Mass.
- Jour. New Eng. W. Wks. Assn.- Journal of the New England Water
Works Association. o. Boston, Mass.
- Mines & Min.- Mines and Minerals. m. Scranton, Pa.
- Min. & Sci. Pr.- Mining and Scientific Press. w. San Francisco.
- Min. Wld.- Mining World. v. Chicago.
- Munic. Engng.- Municipal Engineering. m. Indianapolis, Ind.
- Munic. Jour. & Eng.- Municipal Journal and Engineer. w. New York.
- Pro. Am. Soc. C. E.- Proceedings of the American Society of Civil
Engineers. w. New York.
- Proc. Am. Water Wks. Assn.- Proceedings of the American Water Works
Association. yr. Charleston, S. C.
- R. R. Gaz.- Railroad Gazette. v. New York.
- Sci. Am.- Scientific American. w. New York.
- Tech.- Technograph. yr. Urbana, Ills.
- Trans. Assn. Civ. Eng. of Cornell.- Transactions of the Associa-
tion of Civil Engineers of Cornell University. Ithaca, N.Y.
- Trans. Am. Inst. of Min. Engrs.- Transactions of the American
Institute of Mining Engineers. w. New York.



I. TIMBER DAMS.

A timber dam is cheap in first cost and maintenance and easy to build. For these reasons it is the type usually employed by builders of moderate means who have not the necessary capital to invest in more expensive structures. It has one disadvantage in that it is not impermeable to water, and consequently cannot be used for storage purposes. Its greatest use is in connection with mills, where it is only necessary to raise the level of the water in a stream; and in this capacity it has been found to give excellent results. Unlike masonry, a timber dam can be built on any foundation, even quicksand, a slightly different method of construction being followed under different conditions.

Roughly, timber dams may be divided into four classes as follows: 1. Brush and stone, 2. Log or heavy timber, 3. Plank, 4. Frame.

1. A brush and stone dam is the simplest form of construction. It is made by throwing into the stream, brush, logs, or trees of any kind and size, and weighing them down first with heavy stones, and nearer the top with smaller ones. It is evident that a rude structure like this is applicable only to shallow streams and where it is not desired to raise the water more than one or two feet.

2. Log dams are constructed in many different forms. The simplest of these consists of laying the logs close together in successive layers with the upstream ends slanting downward so as to give the dam a triangular cross section. The bottom layer is extended beyond the others on the downstream side so as to form an apron. On mud bottom this apron is made longer, and sometimes the whole structure is sup-



ported on piles. On rock bed the downstream face may be anchored to the rock, although this is not necessary as the base of these dams are long enough and the vertical pressure sufficient to keep the dam from sliding. Instead of being built solidly of logs, pockets are sometimes left to be filled with stone. On account of the proportionally large base required, these dams are not practicably for height greater than 5 or 4 feet. The pyramidal section shown in Fig. 1 is more economical, but requires heavy anchorage.

Where greater heights are desired the crib construction is used. Fig. 2 is a section of a dam at Butte City, Mont., built in log cribs. The total height is 42 ft.

A log dam is sometimes built as a vertical wall in the shape of a V. In this case the stability of the structure depends upon its arch action. The upstream side is sheathed with plank, and a bank of earth is built against it. Earth thrown on the downstream side is of no benefit as it is soon washed away by water leaking through the dam.

5. A plank dam depends for its stability wholly or partly upon arch action. It may have one or two walls, in the latter case the space between is filled with rock. The walls are usually made of plank not smaller than 2 1/2 inch. If properly constructed it can be made practically water tight. Fig. 5 shows the double wall form of construction.

4. A frame dam is the most scientifically constructed timber dam. It is made of well framed bents carrying a sheathing of plank on the water-face. The bents are spaced in proportion to the load they are designed to carry. Usually they are laid on some form of sill foundation which is either supported on piles (See Fig. 4, a and b) or anchored to rock, depending on whether the bottom is mud or rock. The space



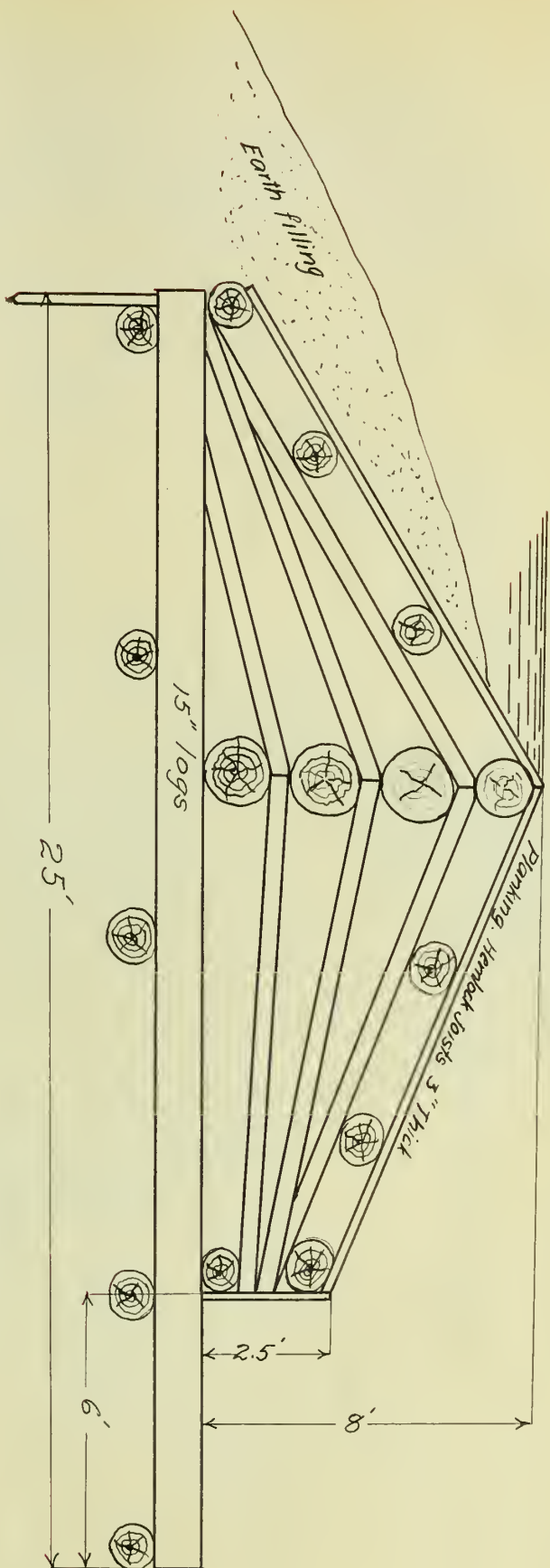


Fig. 1. Log and Plank Dam at Lycoming Co. Pa.



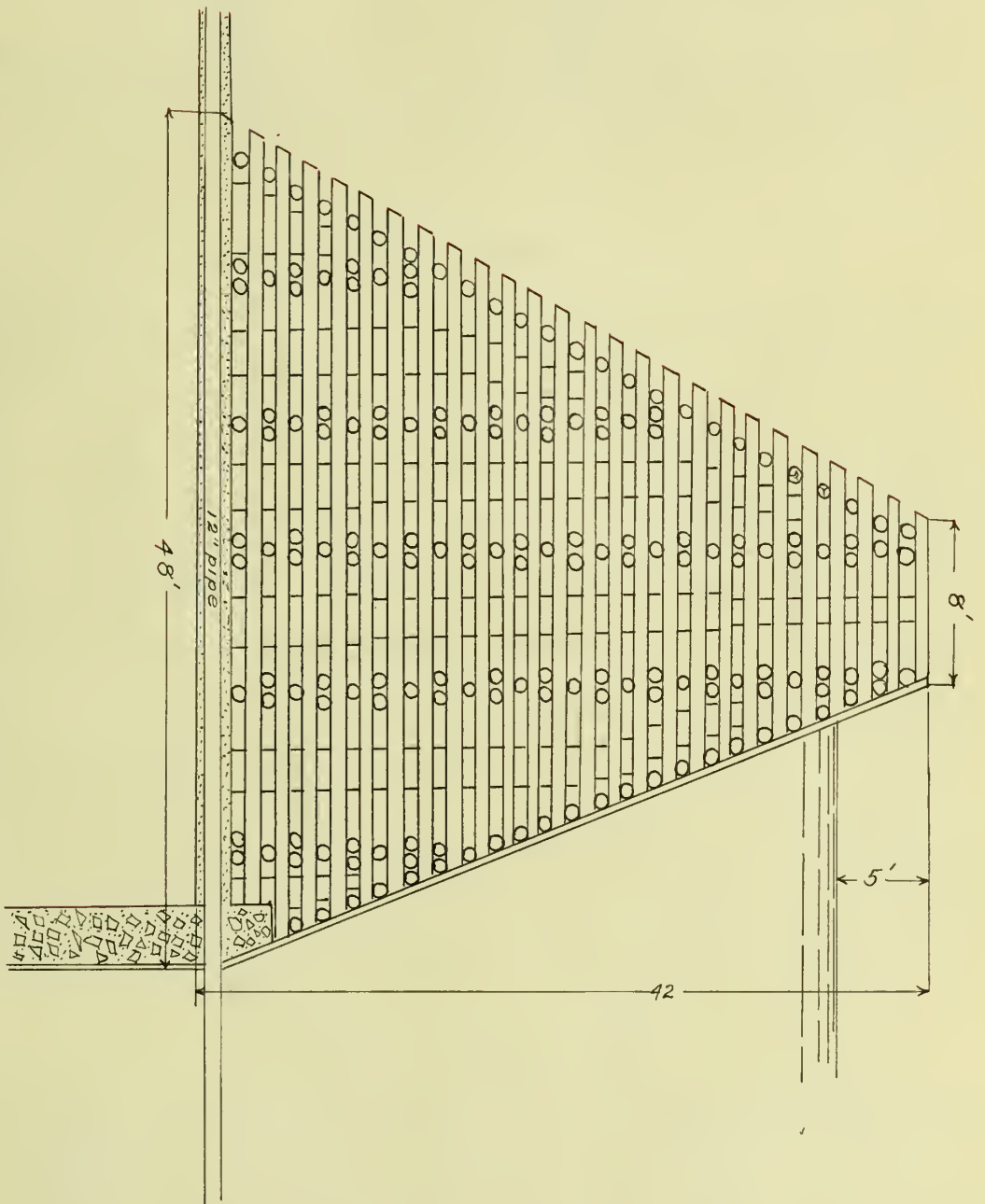


Fig. 2. Log crib Dam for Butte City, Mont.

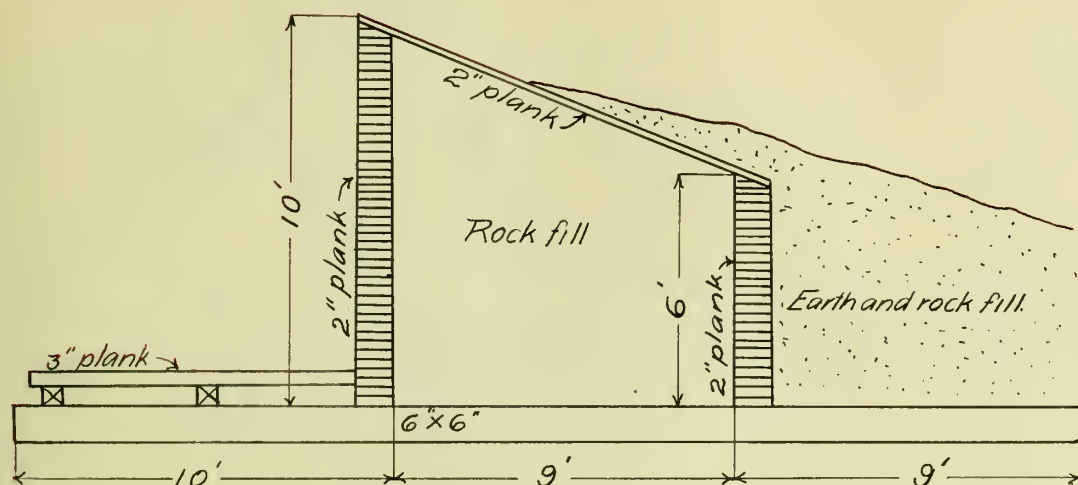


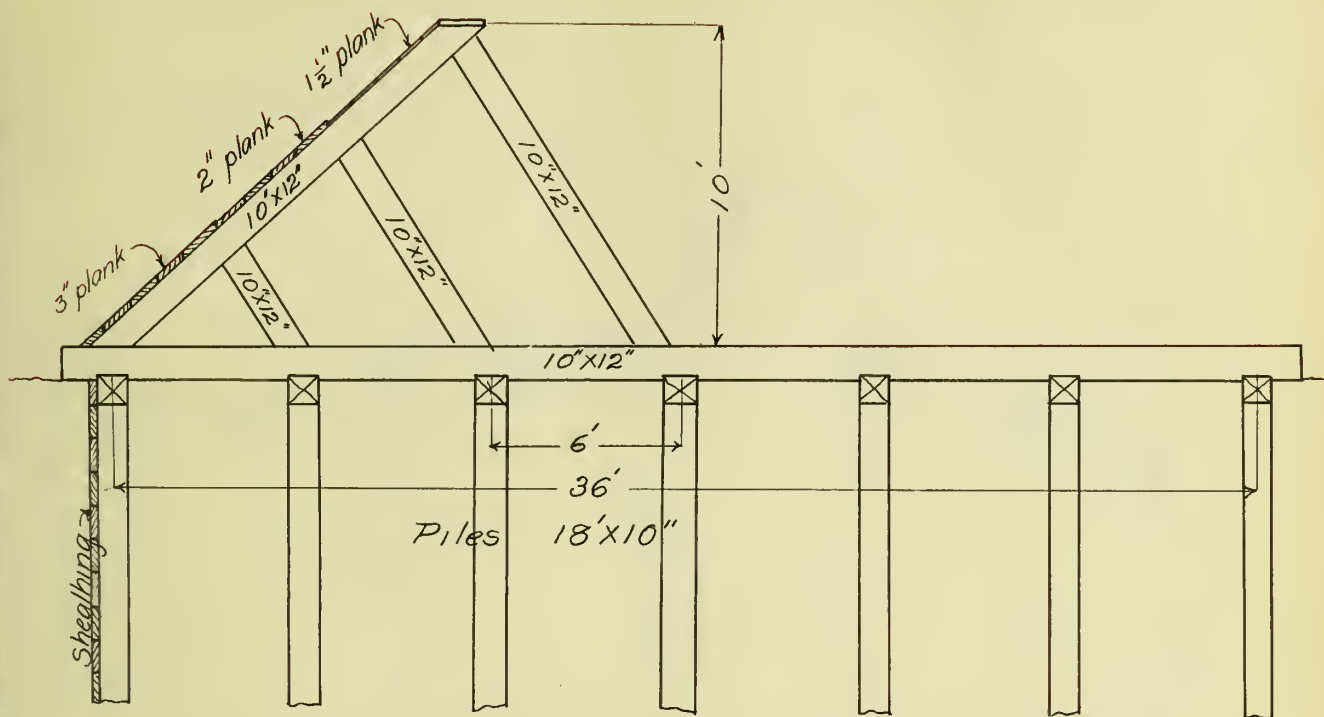
Fig. 3. Plank Dam.

underneath the face may be filled with rock or left hollow. In Fig. 5 is given a section and plan of a very successful low crib dam, at Hartland, Kan. This also illustrates a novel method of preventing silt from depositing behind the dam. The water in rushing between the bulkheads acquires sufficient velocity to wash out the soil that may accumulate. Flash boards are put between the bulkheads to further raise the head of water when so desired. A frame dam may also be laid in a V shape and some arch action developed.

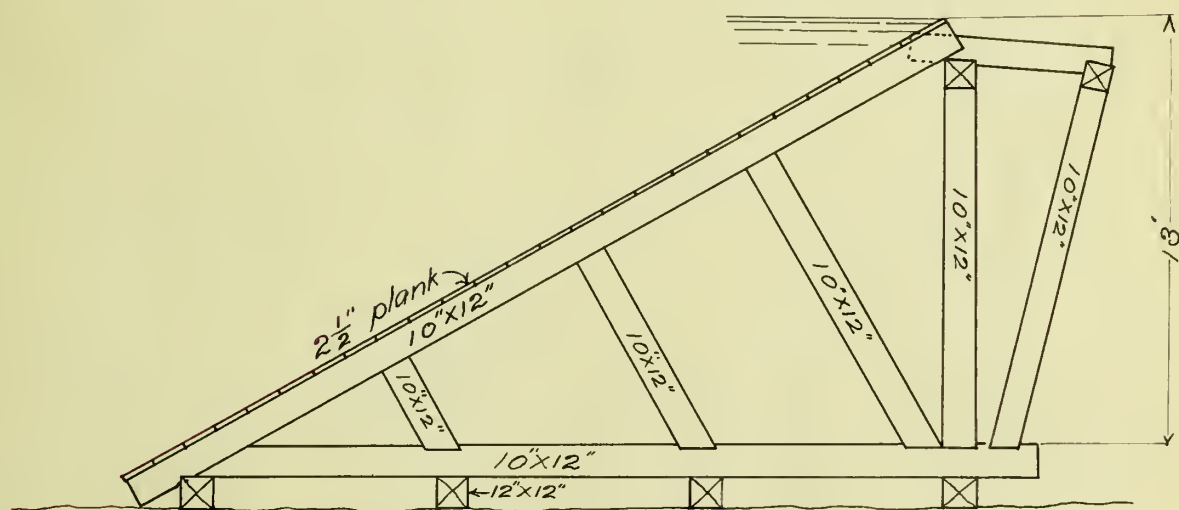
The aprons of timber dams are generally at the bottom and form part of the foundation, but sometimes they extend outward from the top (see Fig. 4b). The former is in general considered the better.

REFERENCES ON TIMBER DAMS.

Leffel's "Construction of Mill Dams" is a practical treatise upon the construction of dams, especially timber dams. The book is devoid of all technical discussion, and deals simply with the practical side of the construction of small dams. For convenience the author of



a. Frame Dam. Mobile Co. Ala.
Quicksand Bottom.



b. Frame Dam with Overhung Apron for Rock Bottom.

Fig. 4. Examples of Frame Dams.

this thesis has classified and rearranged the chapters as follows:

1. Brush, Stone, Earth, etc.

Chapter III. Beaver.

- " XIII. Brush and pile.
- " IV. Brush, stone and gravel.

2. Log and heavy timber.

Chapter IV. Log dam for sand bottoms.

- " V. Log dam built in cribs and rock-filled.
- " VIII. Log dam with crib abutments or vertical and arch action.
- " X. Log and pile.
- " XXVII. Timber crib, with plank covering.
- " XXX. Timber crib at Hartford, Conn.
- " XXXII. Log dam. Vertical and arch action.
- " XXXIV. Timber crib and brush.
- " XXXVI. Timber crib for bottom of quicksand.
- " XLIII. Log and plank.
- " XLV. Double timber crib.

3. Plank.

Chapter XII. Upright arch with crib abutments.

- " XVI. Upright arch for rock bottom.
- " XXVIII. Rock fill at Gilboa, Ohio.

4. Frame.

Chapter VI. Hollow frame.

- " IX. Vertical, straight for rock bottom.
- " XVII. Method of construction between coffer.
- " XXIV. Frame crib at Lawrence, Kan.

Chapter XXIX. Frame arch at Clifton, Ohio.

- " XXXIII. Frame arch at Mad River, Ohio.
- " XXXV. Stone and timber at Renselaer Co., N. Y.
- " XXXVII. Overhung apron.
- " XLI. Frame and pile.
- " XLIV. Frame with sheet piling.
- " XLV. Trestle frame.
- " XLVI. Light frame.
- " XL II. Dam for rock and sand bottom.

DESCRIPTION OF DIFFERENT TYPES.

1. Bodie, Calif. H. 42 ft. Log crib. 1200w Eng. & Min. Jour. Nov. 28, 1896.
2. Butte City, Mont. H. 42 ft. Round fir logs in cribs. 1800w Eng. Rec. Feb. 5, 1900. 5000w W. Jour. Assn. of Eng. Socs. April, '99. Failure of timber crib, 1200w. Eng. Rec. Aug. 6, '96.
3. Big Hole, Mont. Timber crib. H. 57 ft. Jour. Assn. of Eng. Socs. April, '00.
4. Chesuncook, Me. H. 20 ft. Timber crib, rock filled. Eng. News. Sept. 1, '04.
5. Crooker's Reef (Hudson R.). Timber crib. H. 10 ft. Eng. Rec. Oct. 5, '07.
6. Hartland, Kan. Frame crib. H. 4 ft. Eng. Rec. Dec. 5, '03.
7. Holyoke, Mass. H. 50 ft. Eng. News. May 15, '97.
8. Rock River, Ill. Timber crib. H. 4.5 ft. W. Jour. Assn. of Eng. Socs. July, '96.
9. South Yuba R., Calif. Timber crib bolted to rock bottom. Min. & Sci. Pr. Feb. 8, '96.

II. EARTH DAMS.

The earth dam has the advantage of being one of the cheapest as well as the most permanent type of dam construction. It is cheap due to its simplicity, and permanent on account of the fact that it is not subject to disintegration, corrosion or decay as is masonry, steel, or timber. Its use, however, is limited to heights less than 100 to 120 ft. and to conditions where it is certain the water will never flow over the top. For these reasons it is never used to impound water in a river subject to large floods. It is most applicable for storage reservoirs in connection with the water supply of cities or irrigation purposes. Unlike masonry it does not require a rock foundation but can be built on any soil.

An earth dam may be constructed as a single solid mass or with a core wall and either by scrapers or by hydraulic fill. The method without a core wall is used where the material at hand is of a somewhat impervious nature, such as clay, loam, or thick heavy soil, and where great impermeability is not desired. On important structures the upstream face is made impervious by paving it with concrete or stone blocks. Fig. 6 shows the form of cross section commonly used. The breadth at the top, b' , is chosen arbitrarily, and is generally made sufficient to allow room for a roadway. The height, h , should be enough to keep the water from ever reaching the crest. The slope s is generally $1\frac{1}{2}$ to 1, and the slope s' , 5 to 1. However, these values are somewhat governed by considerations of stability. In general, it may be said that the vertical component of the hydrostatic pressure should equal or exceed the horizontal thrust.

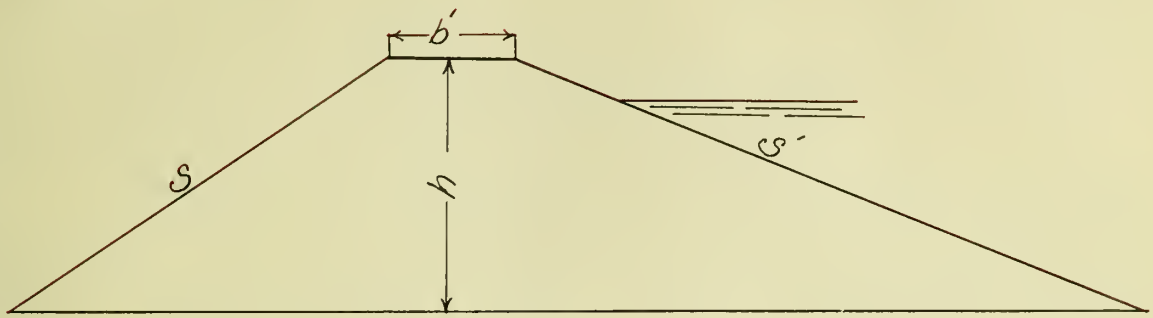


Fig 6 Earth Dam without Core.

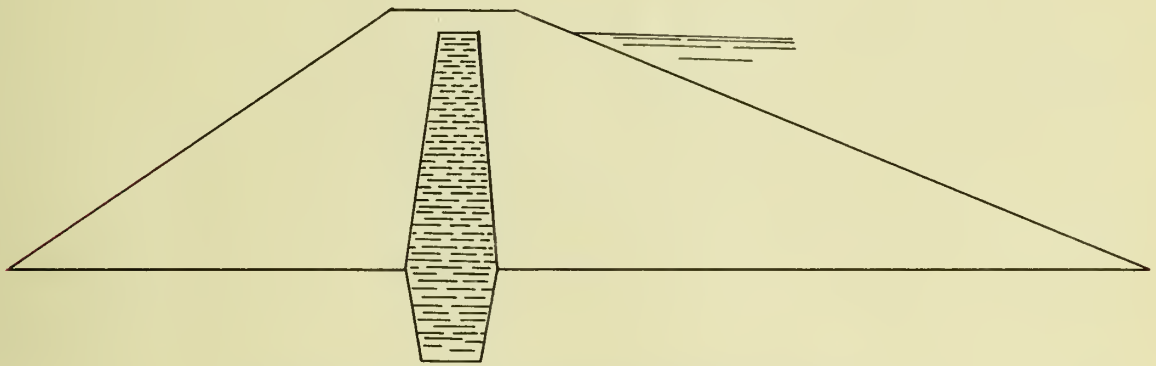


Fig.7. Earth Dam with Puddle Core

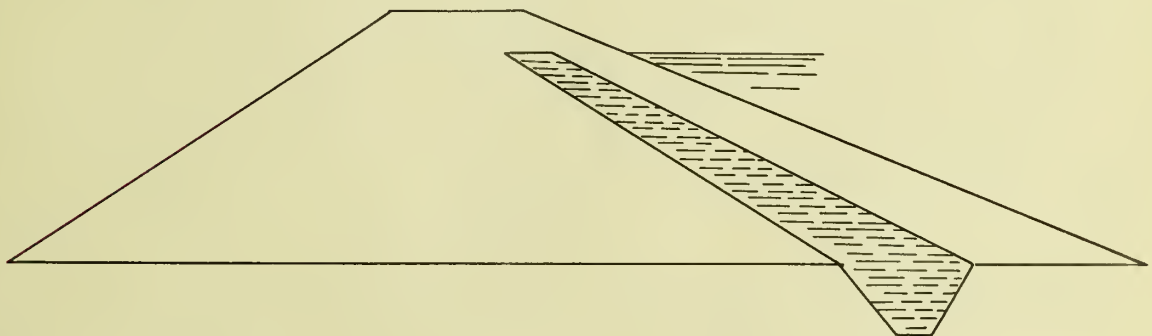


Fig.8. Earth Dam with Inclined Puddle Core.

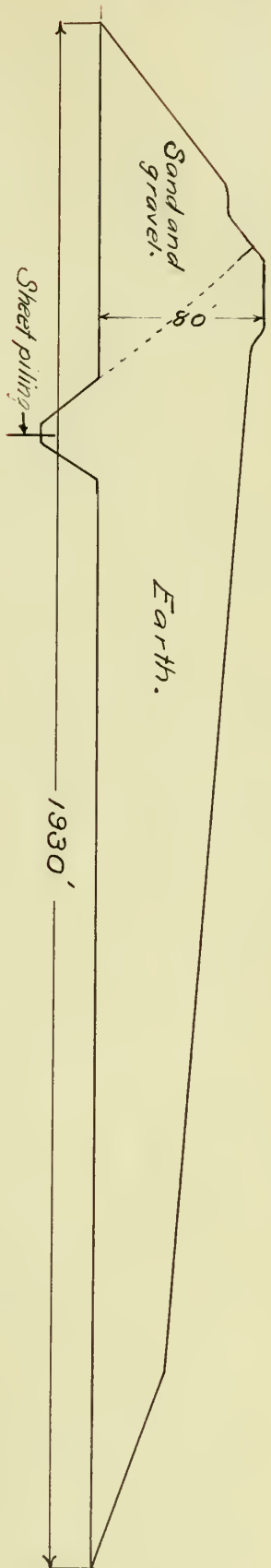
A good example of this type of dam is given in Fig. 9b which represents the Belle Fourche dam in South Dakota. The crest is 6500 feet long, and the embankment is composed of hard compact clay laid in 6-inch layers and rolled with a heavy roller.

To insure greater impermeability an earth dam is constructed with a core wall. This core is either a puddle of clay, loam, or a mixture of these two, masonry, timber, or steel. In some cases different combinations of these materials are used. The general features of a puddle core construction are shown in Fig. 7, and 8.

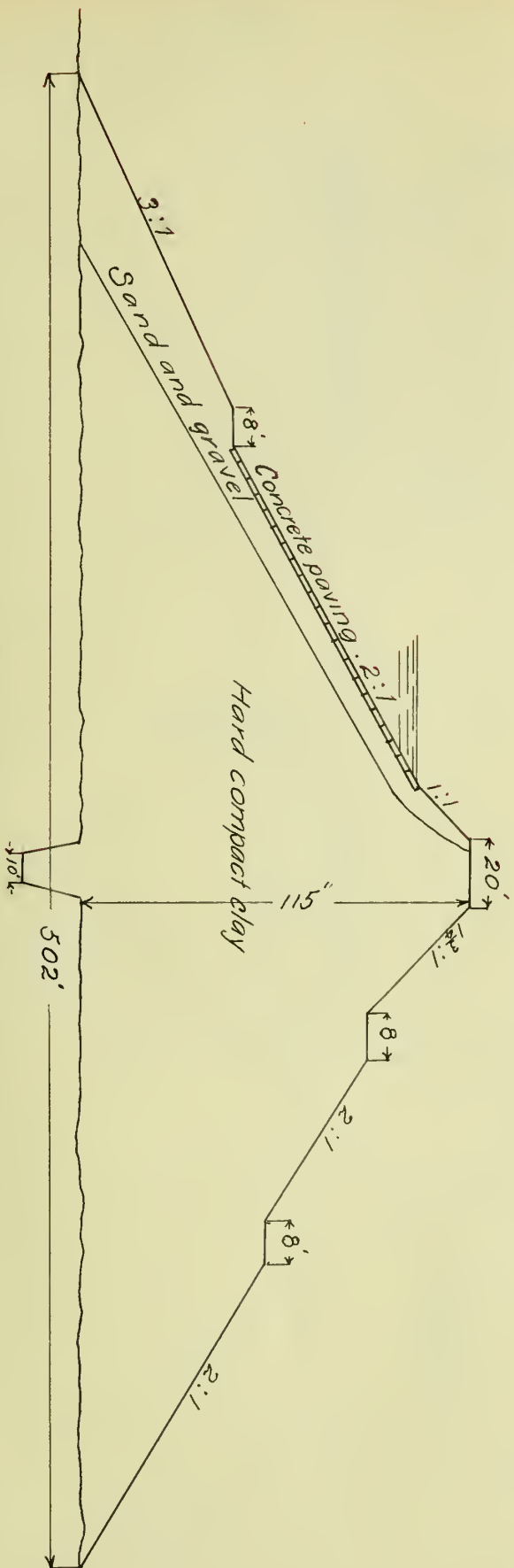
Puddle has the advantage over masonry in that it is light and more yielding, and therefore in settling will not leave cracks as does masonry. Moreover, it is by far the less expensive of the two to construct. Masonry, on the other hand, is applicable to greater heights and also prevents animals from burrowing through. The latter is in some cases a very serious consideration and might make the use of masonry imperative.

Water will percolate even through the best puddle or masonry; and if absolute impermeability is desired the type of construction shown in Fig. 10 is recommended. The core consists essentially of two parallel 8-inch brick walls with a space between which is filled with melted asphalt or coal-tar pitch. The bricks are also laid with asphalt or tar pitch. The core wall is shown carried to rock. For a fuller description of this method see the Eng. News, Feb. 20, '02. Only the almost prohibitive price of this form of construction prevents it from being by far the most superior kind of core wall.

Two typical examples of core wall construction are given in Figs. 11 and 12.



a. North Dyke Wachusett Reservoir.



b. Belle Fourche Dam.

Fig. 9. Examples of Earth Dams without Core Walls.

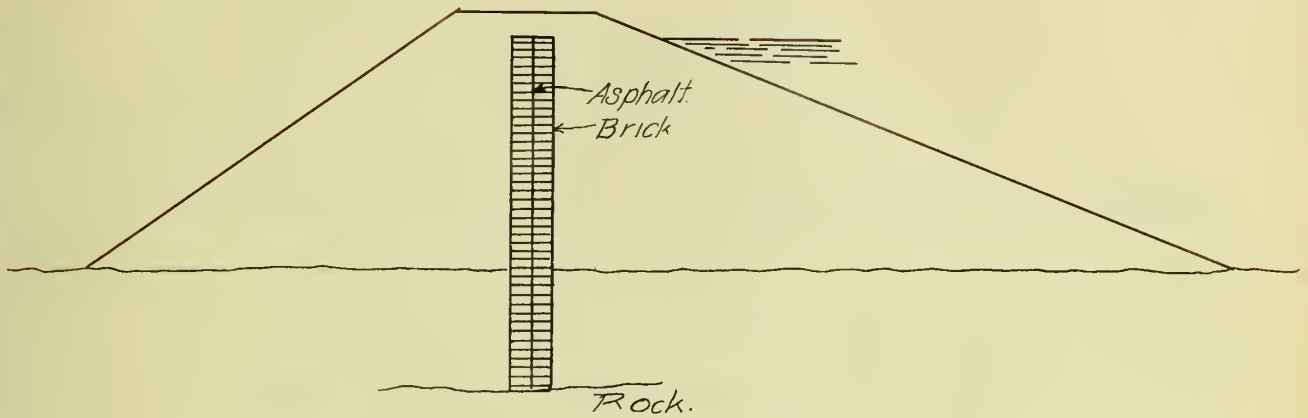


Fig. 10. Earth Dam with Brick Core

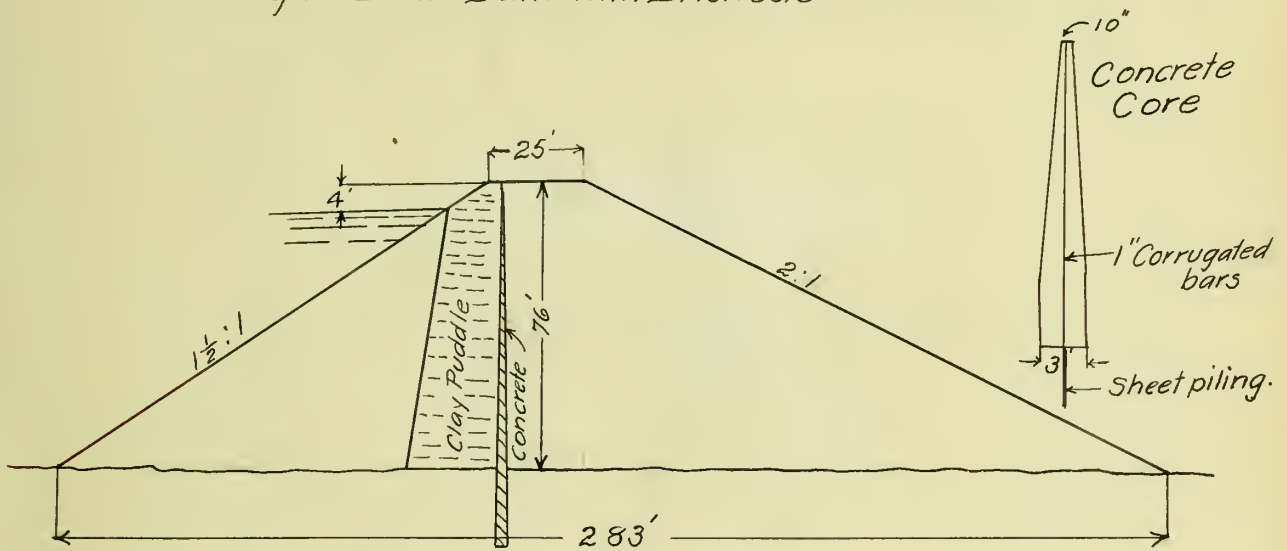


Fig. 11. Earth Dam at Dixville N.H

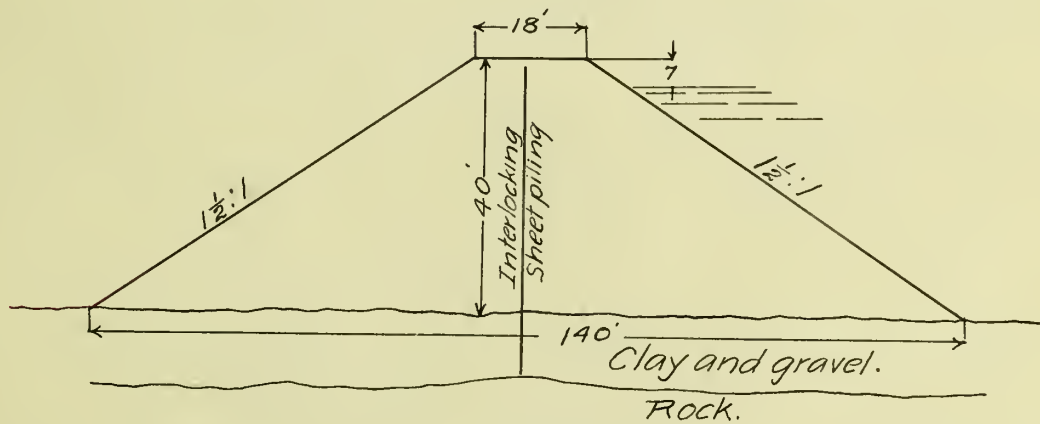


Fig. 12. Earth Dam at Ellsworth Me.

REFERENCES ON EARTH DAMS.

I. Description of Different Types.

1. Arrowhead, Calif. H. 220. BW 910. Concrete core. Hydraulic fill. Eng. Rec. Apr. 5, '09.
2. Necaxa, Mex. H. 195. BW 965. Clay core. Hydraulic fill. Eng. Rec. July 5, '09. Eng. News. July 15, '09.
3. Honey Lake Valley, Nev. H. 96. BW TPP. Clay puddle core. Eng. News. 1894 I. Pg. 217.
4. Utah, East Canyon Creek. H. 68. Rock fill with steel core imbedded in asphaltic concrete. Eng. News. Jan. 2, '02. Eng. Rec. Sept. 2, '99.
5. Colorado, Goose Neck Canyon. H. 210. Rock fill with facing of steel plates. Eng. Rec. Mar. 10, '00.
6. Plymouth, N. H. H. 25. Concrete and puddle core. Eng. Rec. Dec. 21, '01.
7. Labaud, near Jackson, Calif. H. 125. BW. 600. Clay puddle core. Eng. News. July 10, '02.
8. Druid Lake. Baltimore, Md. H. 118. BW. 640. Clay puddle core. Eng. News. Feb 20, '02.
9. Wachusset North Dyke. H. 65. BW. 1950. No core. Details of construction. Report on shrinkage of soil. Eng. News. 1902. I, pg. 566.
10. Wachusset South Dyke. H. 45. BW. 460. Soil core. Serial Eng. News. Aug. 20, '04.
11. Ellsworth, Me. H. 40. BW. 140. Steel core and reinforced

- concrete spillway. Eng. News. Sept. 22, '04.
12. Gatun Pan. H. 85. No core wall. Map and suggestions for a dam. Proc. Am. Soc. C. E. April '04, Aug. '04. Experimental dredge-fill dams. Eng. News. Dec. 24, '03. Report on foundation and construction. Eng. News. Dec. 24, '03. A study of the principles of earth dam design. Eng. News. April 1, '09.
 13. Belle Fourche, S. D. H. 115. BW. 502. No core wall. Concrete paving blocks on face. Eng. Rec. March 5, '06.
 14. California, John Day Dam. H. 85. Concrete core and spillway. Eng. Rec. March 14, '08.
 15. New Hampshire, Dixville. H. 76. BW. 285. Reinforced concrete and clay puddle core. Eng. Rec. Apr. 25, '08.
 16. S. Carolina. H. 52. Masonry core, 15 ft. Timber core, 17 ft. BW. 145. Eng. Rec. Oct. 2, '09.
 17. Chollas Heights, Calif. (Los Angeles Water Supply.) Steel core. H. 56. L. 526. P. 20. BW 500. Eng. News. Apr. 7, '04.
 18. Conconully Dam, Wash. H 59. No core wall. Hydraulic fill. 4500 w. Eng. Rec. Apr. 5, '09.
 19. Moline, Ill. Concrete core 10' to 12' high. River wing dam. Description of the construction of the core wall. 2000 w. Eng. Rec. Feb. 6, '09.
 20. Porto Rico. F 122 ft. Concrete core wall. 1500w. Eng.-Con., Jan. 19, '10.
 21. Arizona. Laguna Dam, Colorado River. H 115. Base 226. 5 concrete core walls. 2500w. Eng. News. Feb. 27, '08.
 22. New Zealand. Goldfield Dam. An earth embankment with impervious face of specially puddled clay. 1200w. Aust. Min.

Stand. Dec. 15, '09.

23. Olay, Calif. H 120, Base 560. Rock-fill with steel core.

3700w. Eng. News. March 10, '98.

24. Echic, Pan. H 100, Base 600. Clay puddle core. Trans. Am.

Soc. Civ. Eng. 1902. Eng. News. Nov. 6, '02.

25. Southbridge, Mass. H 50, L 490, Tw 12, BW 80. Concrete core.

Eng. Rec. Sept. 12, '96.

26. Amsterdam, N. Y. H 50, Tw 15, BW 250, L 408. Concrete core.

Eng. Rec. Dec. 27, '02.

27. Waldon Pond, Lynn, Mass. H 50. Concrete core. Eng. Rec. Dec.

19, '05.

28. Cold Springs, Ore. H 82. No core. Eng. News. March 7, '07.

II. Theoretical Discussions.

1. Behavior of clays in earth dams. 2500w. Eng. News. Sept. 25, '09.

2. Specifications of earth. 1500w. Aust. Min. Stand. June 25, '09.

3. British views regarding earth dams. George K. Yourde. 2000w.

Eng. Rec. July 9, '10.

4. Methods and costs of making two hydraulic fill dams. Date and

information of the building of earth work. 500w. Eng.-Con.

Nov. 15, '07.

5. Earth dams with concrete core wall. 2800w. Eng. News. Sept.

7, '05.

6. Masonry and puddle cores for high dams; their relative merits.

1600w. Eng. Rec. Mar. 29, '02.

7. British practice in building earth dams. 6000w. Eng. Rec.

Feb. 8, '02.

8. Construction of high earth dams. 6000w. Eng. Rec. Apr. 15, '99.
9. Difficulties with earth dams in Great Britain. 4000w. Eng. Rec. Sept. 5, '98.
10. Design and construction of earth dams. Eng. News, 1895, II
pg. 550. Eng. News. Feb. 20, '02.
11. Limiting heights of earth dams. 1500w. Eng. Rec. Dec. 7, '01.
12. Hydrostatic pressure in earth dams. Turneaure and Maurer's
Public Water Supply, pg. 541.

III. MASONRY DAMS.

Masonry dams possess an advantage over earth and timber in that if properly constructed they are practically water tight. They require a solid rock foundation, although small ones may be supported on piles. On account of their superior strength and durability they are used on the more important works. The masonry is either rubble, cyclopean, squared-stone, concrete or loose rock. Regarding the form of construction they are classified as follows:

1. Straight gravity.
2. Curved gravity.
3. Arch.
4. Reinforced concrete.

Each of these in turn may be subdivided into overflow and spillway.

1. The straight gravity type is the most common and is the best suited for wide channels. As they depend for stability almost entirely upon their own weight they become very costly when built to great heights. In designing the cross section it is convenient to use some standard profile such as Hegmann's, shown in Fig. 15. The rock-fill dam may be considered as a gravity masonry dam, although it is constructed of loose rock without a core wall, and resembles the earth dam in cross section. Examples of this type of dam construction is shown in Fig. 14 a, b and c. In a spillway dam the water does not pass over the crest but is taken care of by a spillway constructed for this purpose. A cross section of such a dam is shown in Fig. 15 which represents the New Croton Dam built for the water supply of New York City. In the overflow type (See Figs.

16 and 17) the water passes over the top, the structure thus acting as a weir.

2. The curved gravity dam has its crest or toe curved in order to develop some arch action. In this way the section can be somewhat reduced as the arch furnishes some stability. A typical section is shown in Fig. 18 which is a dam at La Grange, California.

3. For excessive heights the arch dam is the only type that can be used economically. The stability is dependent entirely upon arch action, no allowance being made for any gravitational effect. The only place where this form can be employed is in canyons with precipitous sides of solid unyielding rock that can form suitable abutments to take up the arch thrust. The cross section of the Shoshone dam is shown in Fig. 19. Fig. 20 shows the design for a dam at Las Vegas, New Mexico which is also of an arch type.

4. The reinforced concrete dam is practically a new innovation, and its use so far has been somewhat limited. It is very much more economical than the solid masonry structure and in all cases where it has been used it has given very satisfactory results. It may be either spillway or overflow as is shown in Figs. 21 and 22, respectively.

REFERENCE ON MASONRY DAMS.

1. Description of Different Types.

I. Straight Masonry Dams with Gravity Sections.

a. Without Overflow.

1. Ashokan, N. Y. H 220, L 1000, Tw 26.5, BW 190.2. Cyclopean rubble. 2000w. Eng. News, Aug. 1, '07.
2. Cross River, N. Y. H 150, L 772, Tw 25, Bw 125.5. Cyclopean rubble. 5000w. Eng. Rec. Jan. 5, '07. Sept. 14, '07.

June 16, '06.

3. Cataract Dam (Sydney, N. S. W.) H 154, L 811, Tw 16.5, Bw 120. Cyclopean rubble. 2000w. Engng. Feb. 1, '07. April 24, '08. Eng. Rec. June 6, '08. 1800w. Sci. Am. Sup. Apr. 4, '08. Eng. Rec. Nov. 5, '04.
4. Wachusset. Clinton, Mass. H 205, L 971, Tw 22.5, Bw 187. Rubble concrete. 7800w. Eng. News. 1900 II, 174. 1902 II pg. 211. May 8, '02. Sept. 15, '00. Eng. Rec. Mar. 5, '04. Sept. 8, '00. R. R. Gaz., Vol. XXXIX, No. 5. Mun. Eng. July, '07. Tech. Quar., June, '99.
5. Assuan, Egypt. H 95, L 6400, Tw 17.8, Bw 80.5. Granite rubble. Eng. News, Aug. 14, '02. Eng. Rec., April 22, '05. Sci. Am., Sept. 20, '02. Sup. Jan. 10, '05. Cassier's Mag., Feb., '05. U. S. Com. Rept., Feb. 11, '05. Eng. (Sond.), Dec. 12, '02. June 9, '05. March 51, '05. Eng. Dec. 12, '02. March 9, '00.
6. Croton, N. Y. H 258, L 1200, Tw 18, Bw 185. Rubble faced. Part cyclopean. General description of the work. 1700w. Engr. Sond. Apr. 12, '07. 9800w. Proc. Am. Soc. of C.E., Jan., '07. 1200w. Sci. Am., Sept. 21, '01. 1700w. Sci. Am., Feb. 5, '98. 1200w. Aci. Am., Jan. 20, '98. 2500w Munic. Hour. Eng., June, '05. 4500w. Eng. Rec., March 28, '08. June 20, '05. June 11, '98. Hydraulic ex. Eng. News, Oct. 24, '07. Foundations. Eng. News, May 14, '05. Eng. Rec., Jan. 7, '99. Proc. Am. Soc. of C. E., Jan., '00. April, '00. Criticisms and proposed changes. Eng. News., Dec. 26, '01; Dec. 16, '02; Jan. 9, '02; Nov. 28,

- '01. Proc. Am. Soc. of C. E., Dec. '05; March, '06.
 Sci. Am., May 50, '05; Sept. 21, '01. Eng. Rec., Mar.
 4, '05; Aug. 16, '02; May 50, '05.
7. Dhukwa, India. H 40, Bw 45. Eng. Lond., May 17, '07.
8. Switzerland. Stony Gate. H 29. Eng. News, Aug. 25, '10.
9. Cold Springs, N. Y. H 52. Eng. Rec., July 11, '96.
10. Spring Brook, Pa. H 104, L 230, Tw 9, Bw 76. Eng. Rec.,
 June 11, '04.
11. Chirviscar, Chili. Concrete. H 52, L 525, Bw 52. Eng.
 Rec., March 27, '09.
12. Pipin Brook, Conn. Concrete. H 24, L 250, Tw 3, Bw 16.
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13. Lynchburg, Va. Concrete. H 70. Eng. Rec., May 16, '08.
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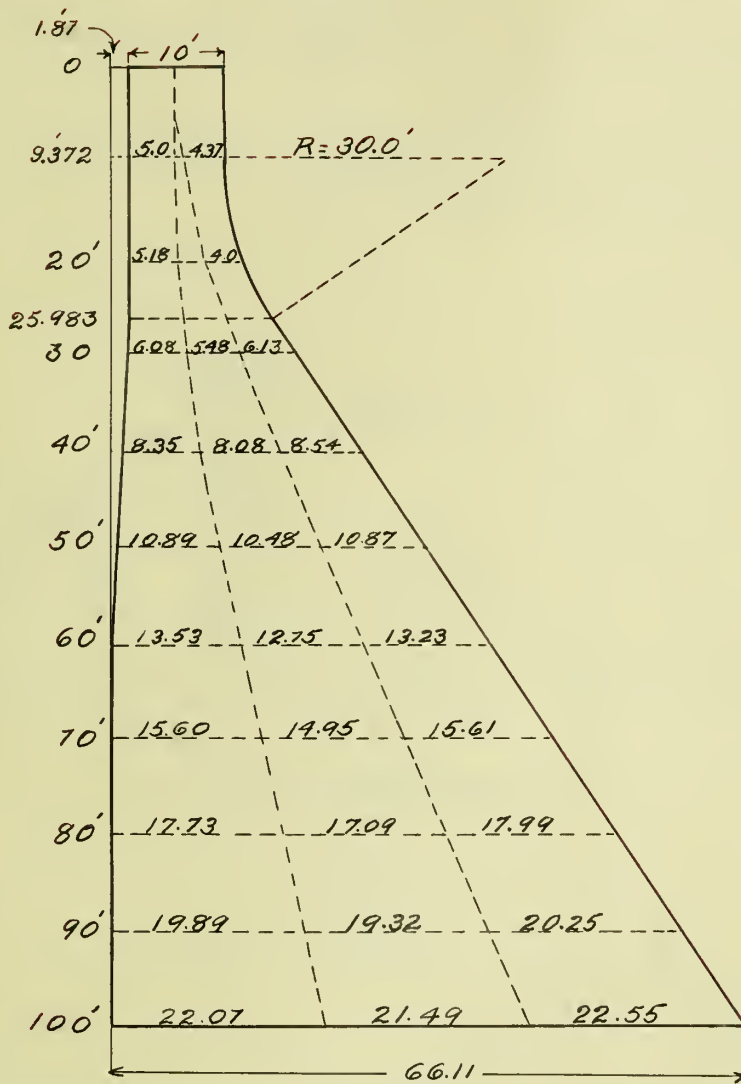
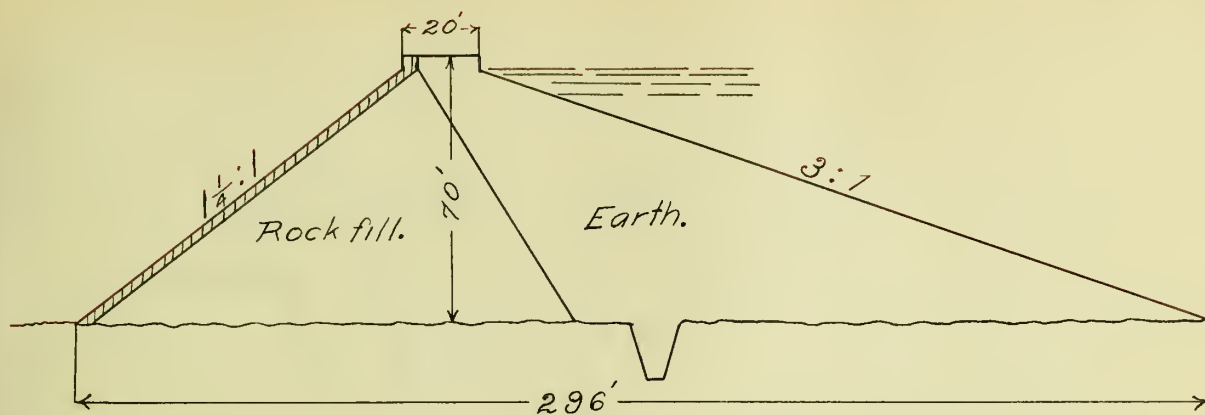
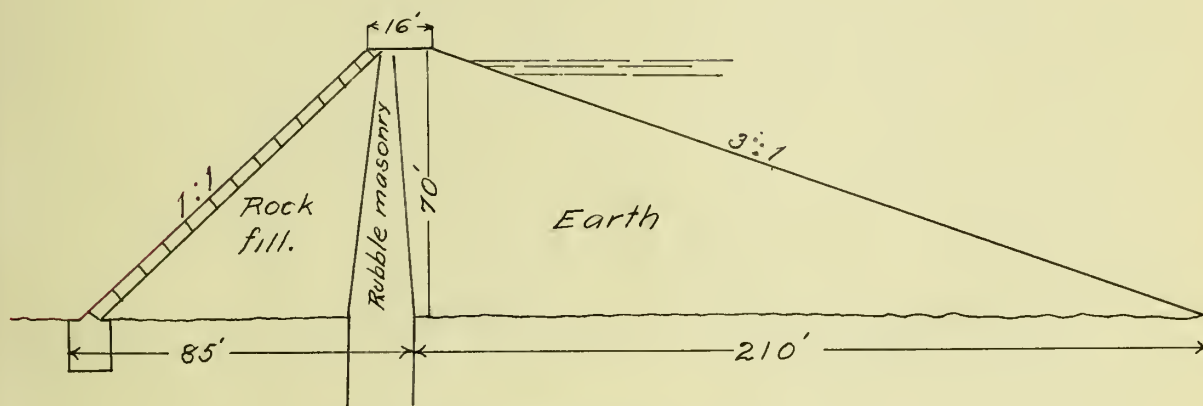


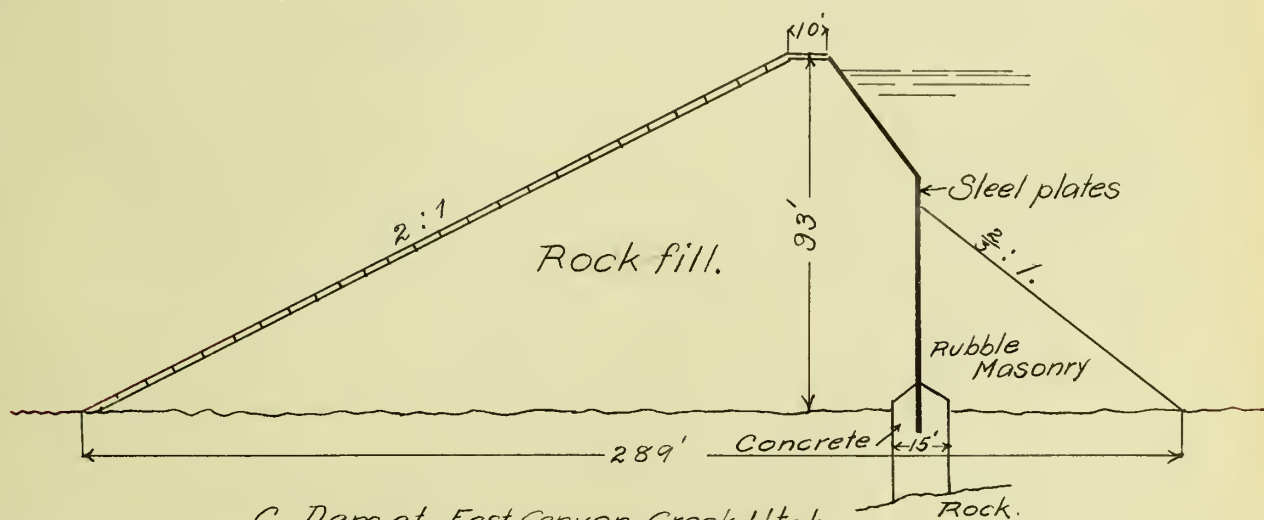
Fig.13. Wegmann's Practical Profile N°2.



a. Dam at Zuni New Mex.



b. Dam at Castlewood Colo.



c. Dam at East Canyon Creek Utah.

Fig. 14. Examples of Rock Fill Dams.

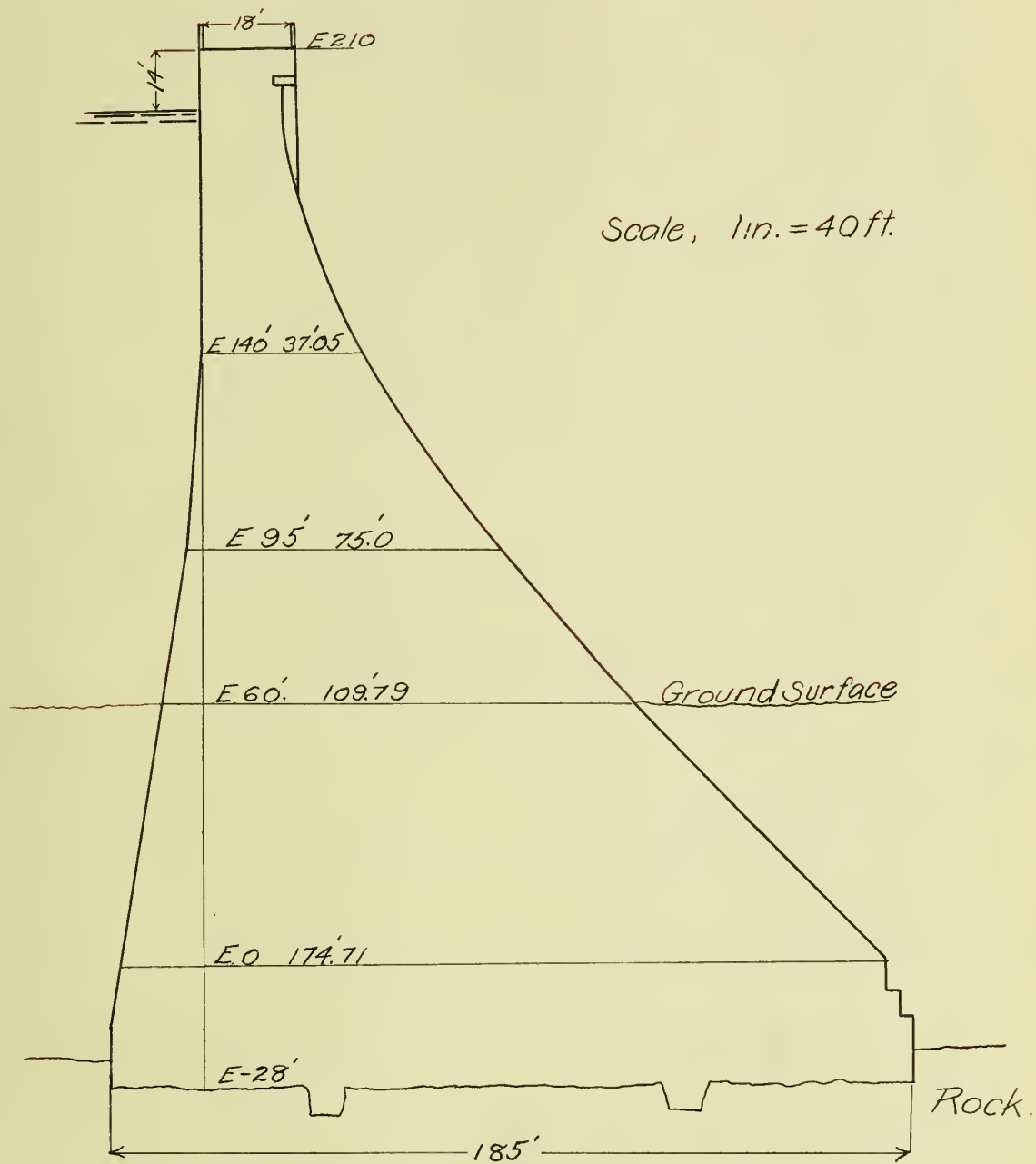


Fig. 15. New Croton Dam.

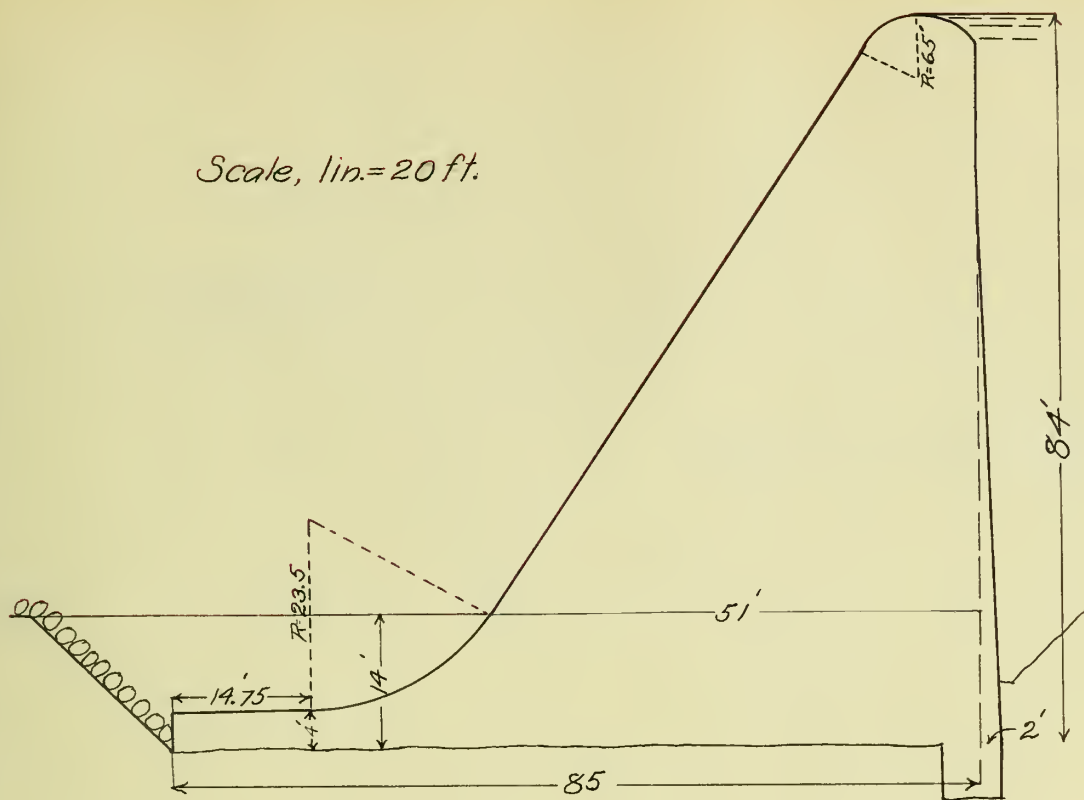


Fig.16. Dam at Rome N.Y.

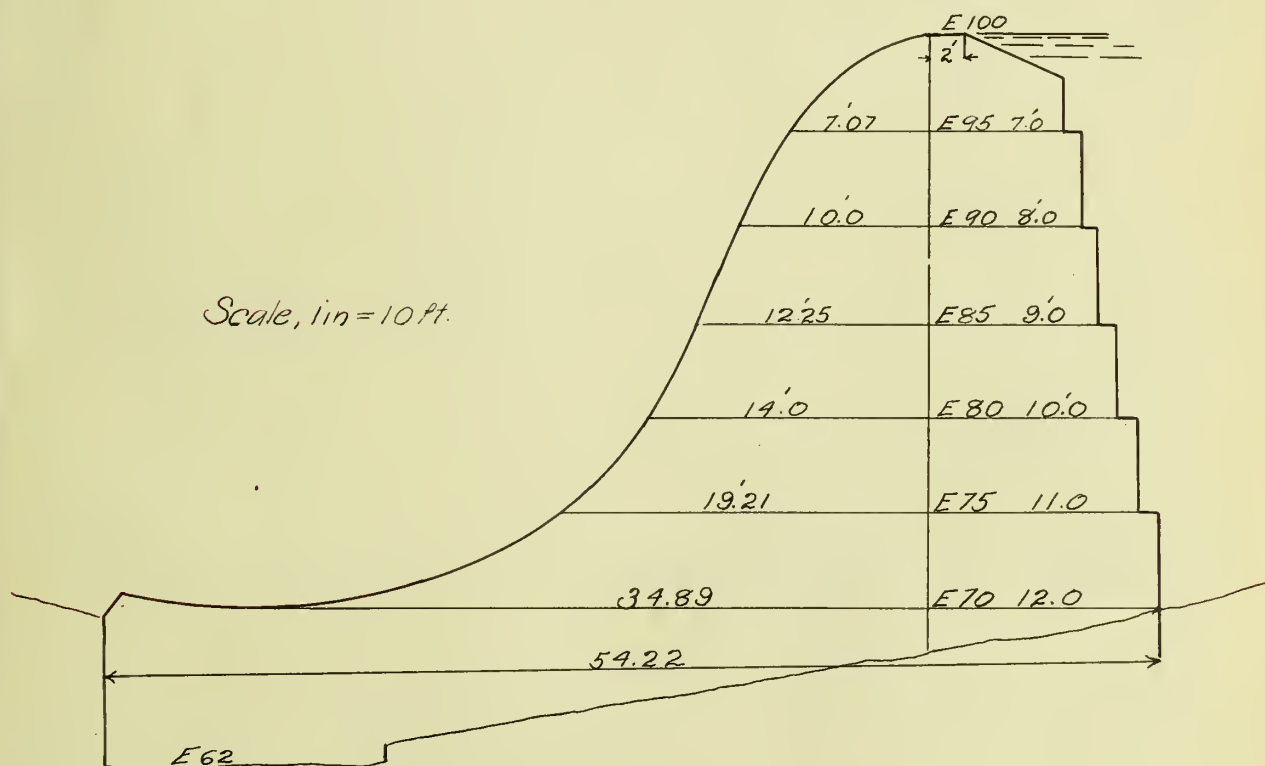


Fig.17. Dam at Holyoke.

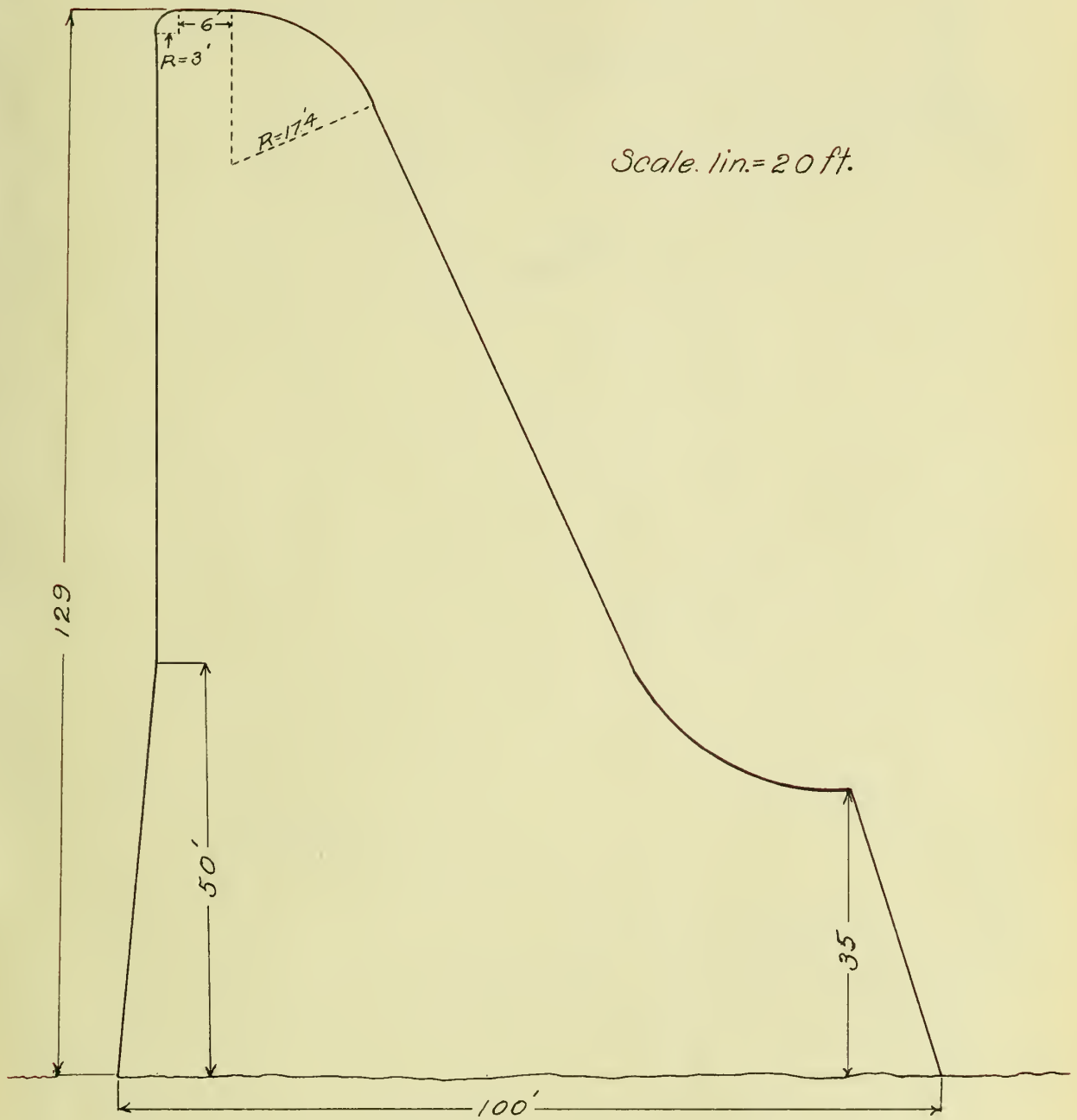


Fig. 18. LaGrange Dam, Calif.

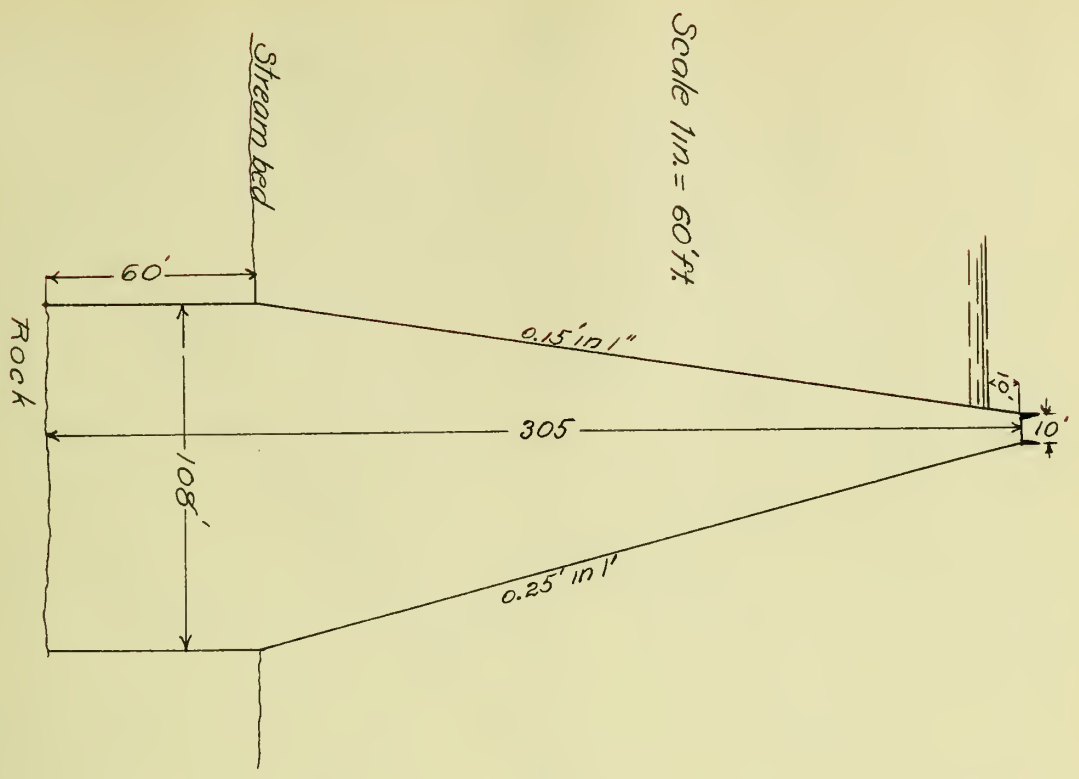


Fig. 19. Shoshone Dam.

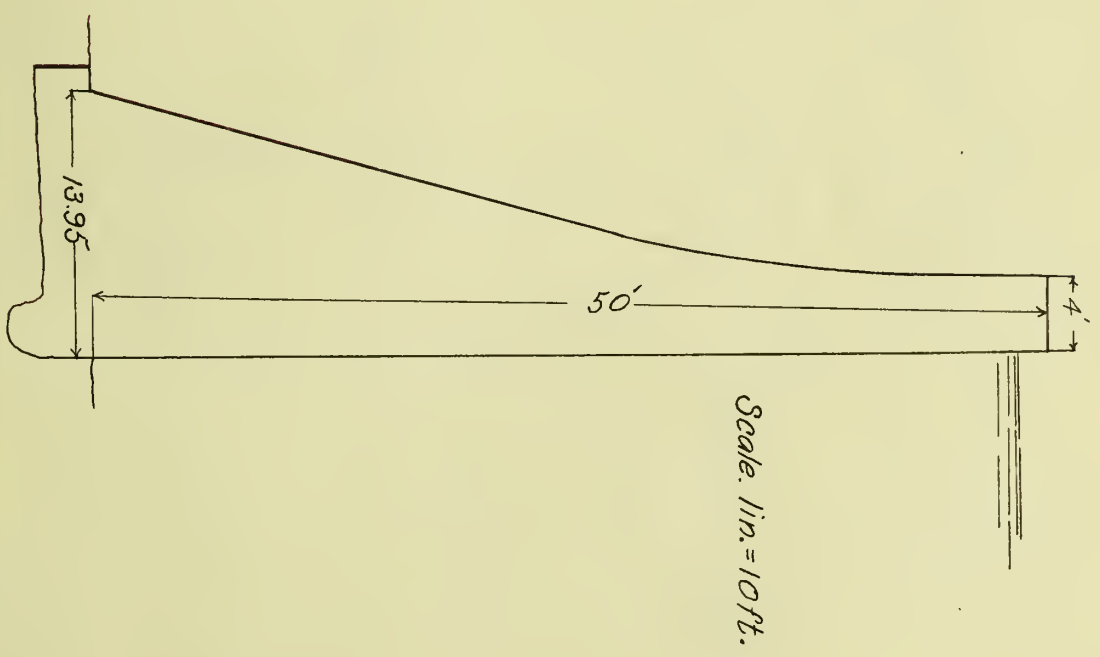


Fig. 20. Dam at Las Vegas, New Mex.

Scale, 1 in = 30 ft.

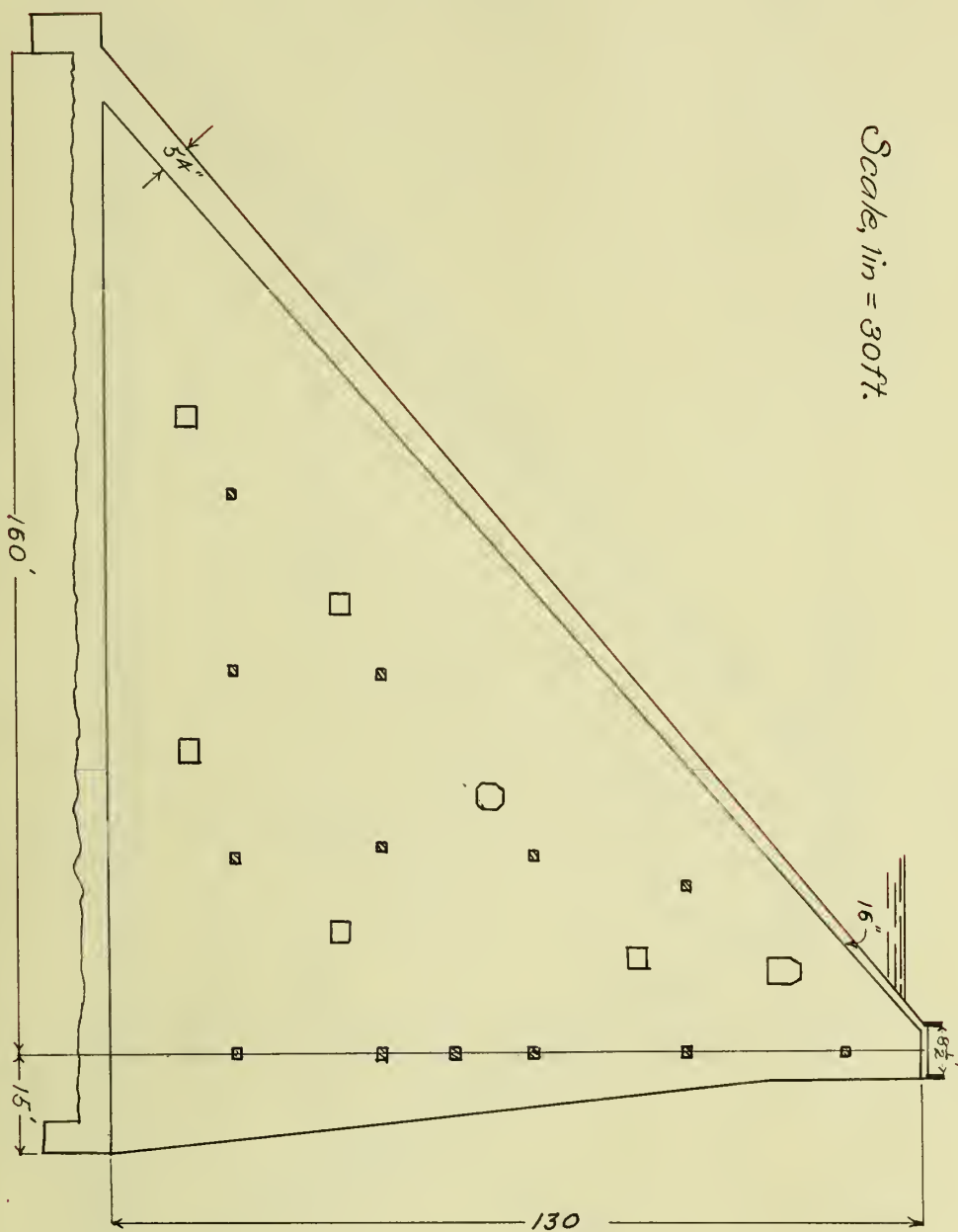


Fig. 21. La Prele Reinforced Concrete Dam.

Scale, 1 in. = 15 ft.

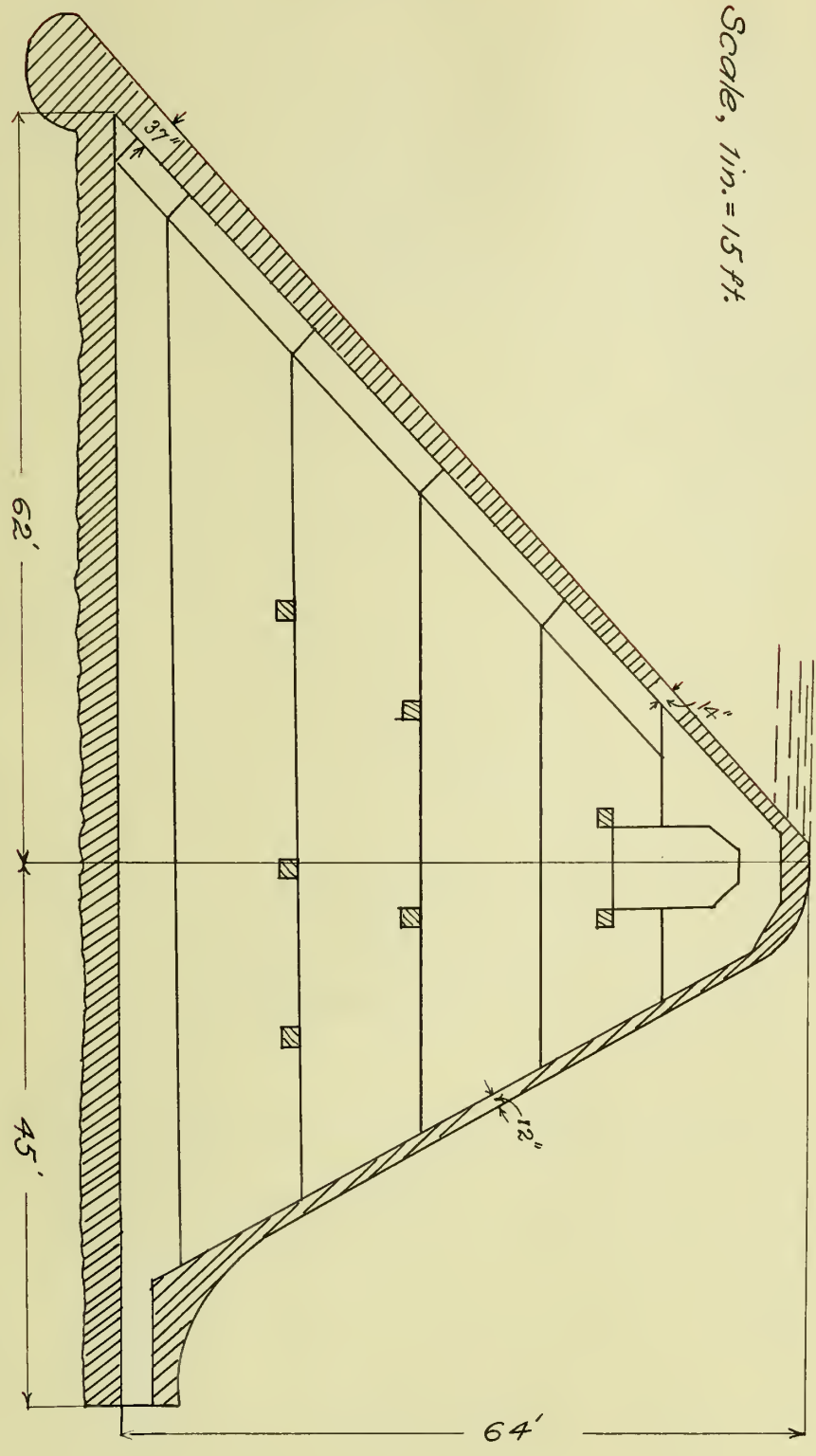


Fig. 22. Reinforced Concrete Dam at Ellsworth Me.

IV. STEEL DAMS.

Steel dams may be either fixed or movable. Fixed steel dams are practically a new innovation, the first one ever constructed being at Ash Fork, Arizona, in March, 1896. (See Fig. 23). Their use to date has been somewhat limited, but their success insures a greater use in the future. In a steel dam the stresses are taken from the face plate to the foundation by means of trussed bents, the members of which are built up sections acting as columns and tension tie-rods. Concrete is used only to seal the toe to the foundation. Leakage through the joints will be considerable unless they are coated over with asphalt or cement. The principal advantages proved to date are that it is very much cheaper than masonry and some engineers claim more durable. In order to prevent rust it is necessary to paint the steel well. The dam at Ash Fork was given a coat of raw linseed oil in the shop and one coat of red lead and an additional one of graphite after erection. Four years after construction it showed no signs of rust on either face. In several other cases it has been proved conclusively that when well painted there is no danger of corrosion.

If the stream bed is rock no special foundation is necessary, only the pedestals for the columns, but on sand or soil it is necessary to construct a masonry base, as is shown in the case of the dam at Redridge, Mich. (Fig. 24).

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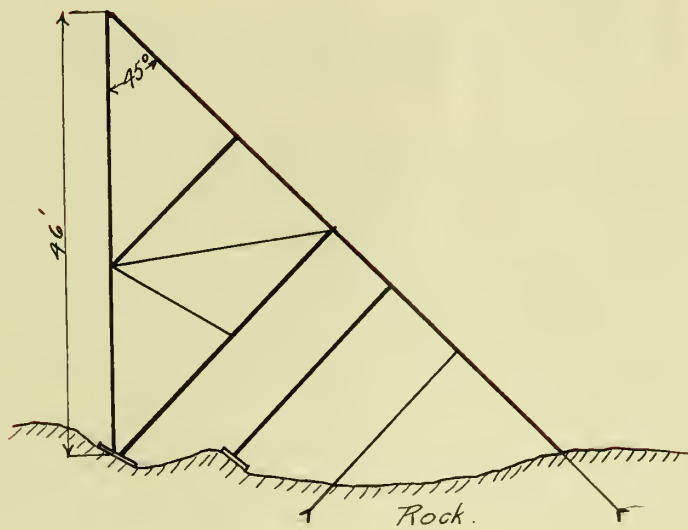


Fig. 23. Steel Dam at Ash Fork, Ariz.

Scale, 1 in. = 20 ft.

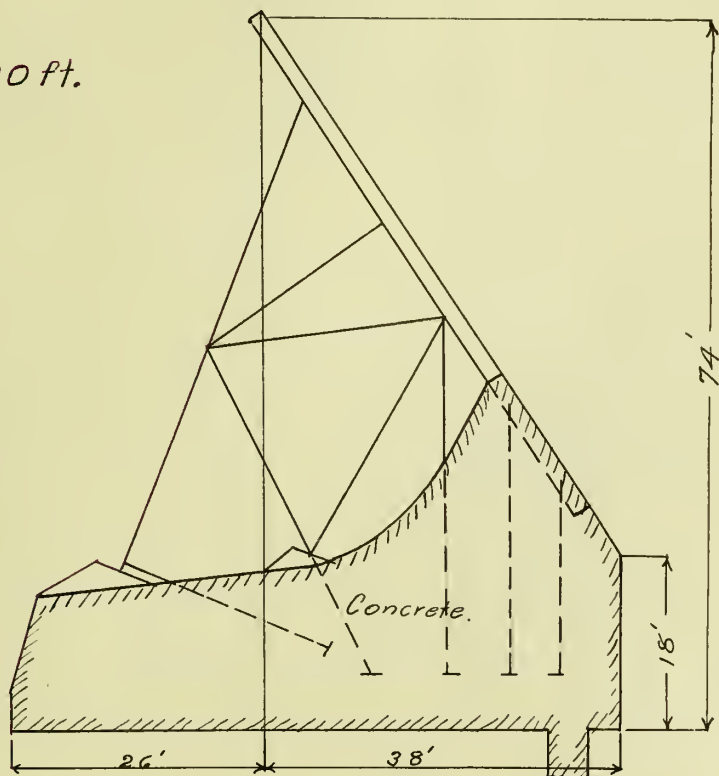


Fig. 24. Steel Dam at Redridge, Mich.

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CONCLUSION.

Dams are called upon to fulfill two different purposes, viz. to impound water, and merely to raise the level of the water in a stream. The first involves the forming of a reservoir for the storage of water, and consequently the dam must be both stable and impermeable; and the second is used a great deal in connection with small water power development and diversion works. In the second case impermeability is not so essential, as the amount of water available is usually in excess of that utilized. It is for this reason that timber structures in which the leakage is in most cases considerable can be used to advantage. All dams must be able to withstand the pressure of the hydrostatic head and also the destructive action of flowing water. Consequently, unless a dam is specially designed as an overflow type it is necessary to provide a spillway of ample size to prevent flood waters from flowing over the crest. It is impossible to give rules for determining the type of structure to be used as this depends entirely upon local conditions and the relative costs of the different materials and these vary greatly with the locality.





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